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(54) **Sensing device**

(57) An optical head (4) for sensing banknotes using six different groups of light sources, namely LEDS generating light at six different wavelengths both in the visible range of the spectrum and in the infra-red range of the spectrum. Unitary light guides (16,18) define the path between linear arrays (8,10) of the LEDs and the surface of a banknote (2). Diffusely reflected light is separately collected by a pin diode detector array (12). Both the LEDs and the detectors are commonly mounted on a single printed circuit board (14). The light sources (8,10) are arranged to shine directly into the light-receiving end of each light guide, which are unitary and allow the light to mix and spread within in order to provide a homogeneous illumination. The detectors (12) are optically isolated and detect discrete areas on the banknote transport path.

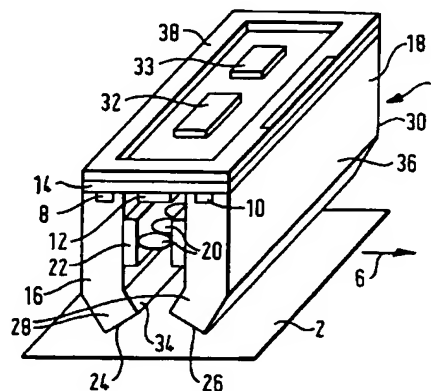


FIG. 1

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transport path.

[0012] A unitary light guide allows the light from light sources within a group to spread and mix within the light guide, so that the light emerging from the light-emitting end of the light guide may approach a uniform intensity across the width of the light guide.

[0013] The use of the unitary light guide which forms part of a first light path coupling to the light generating area to the transport path, and a light detecting area optically coupled to the transport path by a second light path different to the first light path provides that an area on the transport path can be illuminated with a homogeneous light distribution whilst also allowing the detectors to discriminate between a plurality of discrete areas on the transport path.

[0014] The field of view of each of the light detectors may be restricted by light shielding means located between the detectors and the transport path, which reduces the mixing of light from a discrete area being detected by one detector, with that being detected by adjacent detectors.

[0015] The light guide may define an indirect path between the light sources and the part of the transport path being detected, so as to ensure that light is reflected within the light guide at least once before impinging on the sensed part of a banknote, thereby to increase the light spreading and mixing effect of the light guide.

[0016] The light sources may be unencapsulated LEDs, which allows for an increased coupling efficiency between the LEDs and the light-receiving end of the light guide. This effect is further achieved by providing that the light sources may be optically coupled to the light-receiving end of the light guide via a substance, such as a gel, having a refractive index generally matched to that of the light guide.

[0017] The outer surface of the light-receiving end of the light guide adjacent said light sources may follow a generally convex profile in cross section, so as to focus said light sources into the light guide. This arrangement also provides for a greater coupling efficiency between the light guides and the light sources.

[0018] Light guides utilised in other prior art arrangements rely on mismatched refractive index boundaries to ensure total internal reflection within the guides. A difficulty associated with these prior art arrangements is that defects in the reflective properties of the light guide sides are created when the light guides contact adjacent surfaces or fixings. The unitary light guide of the invention preferably has at least one metallised surface. By using light guides which have a metallised surface, physical contact, for example of supports, with the surface in question has far less effect on the reflective properties of the light guide sides.

[0019] The light sources may be arranged in a linear array, with said light guides having metallised sides located adjacent each end of said linear array. This increases the homogeneity of illumination provided at

the light-emitting ends of the light guides by reducing end effects. A series of virtual sources is thus produced at each of the adjacent sides, which mirror the light distribution produced directly by the source arrays.

[0020] Each of said groups of light sources is preferably arranged to be energised during a detector illumination period associated with each of said detectors, each said detector being illuminated in turn. By this mode of operation, the entire spectral range of information achieved by sensing with the different colour groups is more closely associated with a discrete detection area than would be the case if all detector outputs were sensed in sequence illumination by each colour group in turn.

[0021] The light detectors may be arranged on a common substrate such as a printed circuit board, which provides for a simple and cost-effective arrangement.

[0022] A control unit and/or amplifying means for said light detectors may be mounted on the same printed circuit board. This allows these components to be located in close proximity, thereby reducing the creation of noise on the signal lines.

[0023] A further aspect of the invention provides a device for sensing the optical characteristics of a document moving relative to the device in a transport path, comprising a plurality of light sources, a unitary light guide optically coupling said light sources to one side of said transport path, and a plurality of detectors optically coupled to the same side of the transport path externally of said light guide to receive light from said light sources when reflected from a document travelling along said transport path.

[0024] A yet further aspect of the invention provides a sensing device comprising: position-sensing means for sensing the position of a banknote travelling along a transport path; a plurality of detectors for sensing a characteristic of the banknote in different regions spaced across said transport path; and processing means connected to said detectors so as to be capable of processing the outputs of one or more of said detectors in a plurality of possible combinations, said processing means being arranged to select one of said possible combinations, responsive to said position-sensing means, for use in judging said banknote. This arrangement provides for the judgement of a document, such as a banknote, which may be transported in various skew and/or offset positions, on the basis of characteristics sensed in a discrete area of the document.

[0025] Further aspects and advantages of the invention will be appreciated on consideration of the following description of a preferred embodiment of the invention given by way of example only with reference to the accompanying drawings, in which:-

Figure 1 schematically illustrates an optical sensing device according to an embodiment of the invention;

